

Rural R&D for Profit Program

Smarter Irrigation for Profit

RRDP1801 - Leadership and Coordination

Final Report

Cotton Research and Development Corporation

1st July 2017 to 31 May 2018

Dr Guy Roth, The University of Sydney, Narrabri Campus.



Guy Roth and John Smith at a CRDC cotton nitrogen and water use efficiency study site, Yanco, NSW.

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Department of Agriculture and Water Resources
Postal address GPO Box 858 Canberra ACT 2601
Telephone 1800 900 090
Web agriculture.gov.au

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The project, *Smarter irrigation for profit*, was a partnership between the major irrigation industries of cotton, dairy, rice and sugar, and was led by the Cotton Research and Development Corporation (CRDC) in conjunction with Dairy Australia, Agrifutures Australia, Sugar Research Australia and research partners including: CSIRO, NSW DPI, USQ, TIA, SARDI, DEDJTR Victoria, Gwydir Valley Irrigators Association and other industry organisations.

The author would like to thank the project steering committee which provided governance and set the strategic direction of the project. Members of the steering committee included; Jane Trindall, CRDC (Chair), Cathy Phelps Dairy Australia, Peter Sampson SRA, Michael Beer / John de Majnik Agrifutures Australia, Dougal Wallace Victoria DEDJTR, Peter Regan NSW DPI, Richard Rawnsley TIA and Erik Schmidt USQ.

In particular, the author would like to thank each of the project leaders and their teams of the core projects including Joe Foley USQ, Lou Gall GVIA, James Hills TIA, Hiz Jamali CSIRO, Andreas Jaramillo SRA, Andy McAllister DEDJTR, Mike Morris DEDJTR, John Smith NSW DPI and Monique White Dairy SA.

Plain English Summary

Introduction

The project aimed to improve the profit of 3,000 cotton, dairy, rice and sugar irrigators with the support of 16 research and development partners and 19 farmer irrigation technology learning sites. Grower led irrigation research and extension aimed to collect commercially relevant comparative data on different irrigation systems and technologies. The intention was to provide growers improved understanding of the implications for capital investment, management and the resource requirements (water, energy and labour) associated with different irrigation systems and the adoption of automation technology and different approaches to farming systems.

The project consisted of three components.

1. Practical, reliable irrigation scheduling technologies
2. Precise, low cost automated control systems for a range of irrigation systems
3. A network of 19 farmer managed learning sites located around Australia.

The project had key learning sites in Queensland; Ayr, Emerald, Warwick, Dalby, Toowoomba, St George. NSW; Moree, Narrabri, Wee Waa, Tamworth, Aberdeen, Whitton, Jerilderie. Victoria; Numurkah, Shepparton, Macalister. Goulburn Murray Irrigation District, Tasmania; Rocky Creek, Sisters Creek, South Riana, Montana, Cressy. South Australia; Allendale, Eight Mile Creek, Mt Schank. Western Australia; Harvey.

The flagship strategy of the project was use of the key learning sites. These 19 sites were located all around Australia and were mostly on commercial farms. They all involved farmers, advisers, scientists and agribusiness. Thousands of people inspected or visited one of these sites. Some were more “research” focused; testing a hypothesis with robust scientific methods. Others were “demonstration” focused involving monitoring current actions and making changes as experience and confidence grew. One of the strengths of the project was having both approaches.

Extension activities conducted by the project have resulted in the project being promoted to over 3000 irrigators and industry personnel at a range of field days, field walks and workshops.

Several activities targeted sharing knowledge and collaborations across different sectors of rice, cotton, sugar and dairy. These included bus tours to other industries, social media, workshops and farm field days.

Key Findings

Irrigation System Selection

There is no universal best type of irrigation system – even within a region and a production system. It is a matter of selecting the system that offers the best fit for purpose. Considerations include topography and soil types, the nature and security of the water supply, and the style of management. Establishment (or conversion) costs and payback periods, along with productivity, water use, and operating, labour and energy costs affect the attractiveness of options.

Smarter Irrigation for Profit compared different systems and showed their various strengths and weaknesses, and how they varied in different seasons – enabling irrigators to make more informed choices. A key message for farmers evaluating irrigation system comparisons is to look for long term data over several irrigation seasons (wet, dry, hot, cool).

Smart Automated Irrigation

Irrigation System Design & Drainage

Surface irrigation (be it by furrow or in bays) is the most common form of irrigation due to its low capital cost and low energy requirements. Well-designed and well-managed surface irrigation can achieve application efficiencies of 95% - showing that efficiency comes from design and management, and is not an inherent characteristic of the system itself.

Smarter Irrigation for Profit trials showed that application efficiencies for surface irrigation can often be improved by better design and scheduling – reducing losses through deep drainage and run-off. Key measure; measure to manage.

Irrigation System Efficiency

Smarter Irrigation for Profit included on-farm audits of energy efficiency and irrigation uniformity (checking that irrigation systems are performing as they were designed to). They exposed considerable variation in efficiencies – even with recently installed irrigation systems.

The audits showed that many farmers could save money and improve productivity by running periodic checks or audits and giving attention to maintenance. Irrigators should also ensure suppliers provided a commissioning test before hand-over, to ensure equipment is operating within specification.

Irrigation Monitoring Practice

Scheduling irrigations to provide plants with the right amount of water, at the right time, depends on knowing what is happening in the soil and to the plant. Models or ‘rules of thumb’ can contribute, but monitoring is a mainstay for accurate scheduling. Monitoring options range from high-tech to low-tech and encompass soil-water, plant condition, and weather (especially the weather conditions influencing evapotranspiration).

Smarter Irrigation for Profit explored innovative options for plant sensing, including infrared canopy sensors to detect stress, remotely sensed data and the use of smartphone cameras mounted on irrigators. It also trialed the use of drones equipped with a thermal-infrared camera to provide real-time information on the advance of surface irrigation to enable smarter scheduling, and demonstrated the value of a network of autonomous rain-gauges to improve water budgets and irrigation scheduling.

Irrigation Scheduling Practice

Irrigation scheduling is determining when to irrigate, at what rate, and for how long. It’s about getting the timing, volume and rate right for optimum crop growth or yield. Scheduling uniform applications (e.g. to maintain a water balance) is a first step toward efficient irrigation. Adding elements of precision – varying application rates in response to variations in soil type or crop requirements – is another step. Increasing the degree of precision even further, (e.g. with a wide array of real-time sensors or sophisticated scheduling software), is another.

Evidence in the project found progressions like improved scheduling can produce step-changes in irrigation operations. Smarter Irrigation for Profit has assessed scheduling tools, enhanced some selected options, and promoted wider appreciation of the gains in production and profit from improved scheduling. A report was compiled summarising the pros and cons of the many tools in the market place. This report is on the internet.

Precision Irrigation

Poor irrigation uniformity results in areas of over and under-watering on uniform paddocks, but more precision is needed if all parts of a variable paddock are to be irrigated optimally.

Precision irrigation relies on being able to monitor variations in the water needs of plants and to variously apply water to meet them. Sophisticated irrigation scheduling is used to link the monitoring with more precise irrigation. Smarter Irrigation for Profit trialed and further developed variable rate irrigation systems, improved scheduling for more precision in furrow irrigation, and tested

Smart Automated Irrigation

sophisticated scheduling tools with the potential to control fully autonomous variable rate irrigation systems.

Irrigation Automation

The flow of irrigation water can now be controlled automatically from source to within a field. It relies on sensors and telecommunication to control automated equipment, permitting the remote control of irrigation through a computer or smart-phone interface. Coupling automation with precision scheduling packages ensures the resultant irrigation is optimal, not just the remote control of automated, poor practice.

Smarter Irrigation for Profit trialed automated systems across several commodities and irrigation systems. It found significant benefits to irrigators through convenience and time-saving, as well as improved irrigation practice. The work showed that highly automated, if not autonomous (self-controlling), systems are feasible, and they have potential for continued development and wider application. Automation can be phased into a farm beginning with simple monitoring.

Learning and Capacity Development

Grower-led, field scale trials were widely used to show the practical implications of incorporating new technologies. The network of 'optimised farms' enabled exploration of the issues behind farm scale performance that are otherwise left to early adopters to sort out. It also provided a ready platform for farmers to share directly with other farmers through field days, videos and pod-casts – and it helped researchers see issues from irrigators' perspectives.

Cross Sector Research Directions

Cross-sector collaboration, initiated through the Rural Research and Development for Profit program, has generated considerable interaction, knowledge sharing and collaboration between research institutions to generate the findings presented in this report. Research needs, to build on the findings to date and could include:

- Monitoring – robust and novel soil moisture and crop sensors, pasture growth rate monitors, and infrared canopy sensor commercialisation.
- Scheduling – enhancing scheduling tools, remote sensing, and adaptation of tools to different production systems.
- Automation – improving components, and integrating them into practical, user-friendly systems.
- Climate risk – better managing drought, heatwaves and low water availability.
- Design for adoption – incorporating social science to design 'adoptable' solutions for irrigators.
- Capacity development – building on the optimised farms network and further exploring the complexities around water, labour, energy, nutrition and net profit.
- Agronomy – optimising production from available water with different crops or pastures
- Future researchers – Postgraduate training for the next generation of researchers
- Addition of some more key learning sites including the evolution of this project to greater partnerships with the services sector.

Further investment in topics such as these and others will maintain the momentum of technical advancement in Australian irrigation to generate gains in productivity and profit, and optimize the sustainability of irrigation as a water use.

Conclusions

Hallmarks of Smarter Irrigation for Profit include:

The research emphasis in Smarter Irrigation for Profit on design, sensing, scheduling, precision irrigation and automation, has advanced technical solutions for improved productivity and profit in Australian irrigation.

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Collaboration between research agencies, commercial interests, commodities and other parties has resulted in the sharing of ideas, and the faster and wider trialing and demonstration of new technologies.

The participative and applied nature of the work, well-illustrated by the network of grower-led, on-farm learning sites, has helped ensure technical solutions addressed irrigator's needs in a practical way.

Smarter Irrigation for Profit has primed investors, researchers, commercial interests and irrigators for another wave of research, development and extension for continued innovation in irrigation practice.

The Outcomes

- Evidence of 10-20 percent improvement in water productivity, efficiency and farmer profitability in the case studies.
- Adoption of new irrigation technologies and science application by farmers and irrigation professionals to improve farm profits.
- Significantly, improved cross sector industry research collaboration with public and private sectors in four major irrigation industries providing a legacy platform for other sectors to also benefit.

This project;

- ✓ Provided scientific leadership and strategy direction
- ✓ Created a project culture to foster collaboration
- ✓ Fostered stakeholder collaboration on a national scale.

Evaluation

The Independent evaluation of the project found

“Smarter Irrigation for Profit has been a very effective cross-sector collaboration, generating and extending cutting edge technologies, and working closely with irrigator networks, commercial interests and the managers of ‘optimised’ irrigation farms. “

“The project has built a sound extension network, strengthening existing extension pathways.

The private sector and other regional parties have been engaged by the Project as part of the extension networks, and commercial interests have contributed to the research - providing ideas and innovations for testing, as well as equipment, software and advice.

The cross-sector collaboration, and that between Project investors, researchers, irrigators and the private sector, has been a major contributing factor to the benefits coming from Smarter Irrigation for Profit. Cross-sector collaboration, as part of the Rural R&D for Profit program, was the nucleus around which the Smarter Irrigation for Profit Project formed. It shaped the nature of the Project and has helped address the challenges of a short project (which has in effect been about two and a half years in duration).”

(Source: Resource Strategies Pty Ltd 2018. Evaluation of the Smarter Irrigation for profit project, April 2018.)

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A separate independent evaluation of the entire Rural Research for Profit program found

“This project provides a good example of large scale cross industry collaboration, involving multiple RDCs and partner organisations across Australia. Led by CRDC, other partner RDCs included AgriFutures, DAL and SRA.

There are also many partner organisations involved from across university, state government and private sectors, including primary producers, University of Southern Queensland, Tasmanian Institute of Agriculture, CSIRO, NSW Government Department of Primary Industries, DairyTas Board, South Australian Research and Development Institute, Dairy SA, Victorian Government Department of Economic Development, Jobs, Transport and Resources, Gwydir Valley Irrigators Association, Sundown Pastoral Company and Auscott.

It is also large and complex in the of number trial sites and their broad distribution across regional Australia. There are 19 sites in total in Ayr, Emerald, Warwick, Dalby, Toowoomba, St George, Moree, Narrabri, Wee Waa, Tamworth, Whitton, Jerilderie, Numurkah, Shepparton, Macalister, Goulburn, Murray Irrigation District, Rocky Creek, Sisters Creek, South Riana, Montana, Cressy, Allendale, Eight Mile Creek, Mt Schank, and Harvey.

From an RDC perspective, this project provides a focal point for greater collaboration across RDCs and the government sector, and this was identified as an area for increased collaboration and extension in the future.

It was clear from interviews that project participants value the trust built up across the group, and they felt interests had been balanced and equal participation encouraged. As commented by one project participant:

It's been a good honest forum. Not like some, where you get into them, and you know the bloke across the table is holding a few cards back.

This project also provides an example of farmer led collaboration, as farmers are collecting the commercially comparative data on different irrigation systems and technologies as they trial the different automated irrigation scheduling systems on farms. Two satellite-based scheduling irrigation performance pilots are also being implemented on commercial dairy farms in Northern Victoria. Interviews with RDC representatives commented on how the collaboration has successfully involved farmers as part of the research.

Farmers involved in the project commented on the impact of the project to their farm practices. For example:

I've now fully automated the farm. It's made a massive difference. We have proper records of water usage and we can manage our irrigation much better.

It's also meant I've saved money on hiring people. I was lying in my hotel room in San Francisco and wats still able to turn my pumps on.

The project also evidences how new collaborations between farmers in the sugar, cotton, rice and dairy industries have been formed, via a number of activities such as bus tours of young farmers to other farms and presentation by groups at major workshops. As commented by one farmer involved:

... talking to others, you could see that we faced the exact same issues across industries. It's good to find out what other people are doing to make me think about how I could apply it differently on my property.

1 Project rationale and objectives

This project evolved from direct discussions and reviews within the National R D & E Framework Water use in agriculture strategy. In the broadest context the need for the project was that greater competition and scarcity for water means farmers must become more efficient and productive.

Globally, irrigated agriculture covers about 20% of agricultural cultivated land – but accounts for 40% of global food production. This use of Australia’s water resources produces 30% of the nation’s agricultural production and contributes \$12 billion in export income. More than 80% of all fresh fruit and vegetables are produced using irrigation and in many regional areas irrigated production is the most significant and profitable land use. The impressive, continued increase in productivity of irrigated production would not be possible without improvements resulting from research, innovation and application.

The effects of on-going changes in governance and regulation of Australia’s water resources, and the digital revolution of communication and computing, have brought a new era to irrigation practice.

Improved irrigation system hardware, along with new communication technology and stand-alone and networked instrumentation, provide an unprecedented opportunity for a step change improvement in irrigated water productivity; providing an opportunity to break the nexus.

Realisation of this opportunity and a concomitant improvement in irrigated business profit is only likely if the need for change is identified and the combination of learning, deployment and maintenance of know-how, technology and practice is implemented. This is the setting for the Smarter Irrigation for Profit project.

Smarter Irrigation for Profit

The Smarter Irrigation for Profit initiative was a collaborative, cross-sectorial research project focused on:

- Practical, reliable irrigation scheduling technologies,
- Precise, low cost, automated control systems for a range of irrigation systems, and
- A network of farmer-managed learning sites, located in major regions and referred to as ‘optimised irrigation’ farms.

The Smarter Irrigation for Profit Project involves Rural Research and Development Corporations (RDCs - Sugar, Dairy, Rice and Cotton) and numerous research institutions, coordinated by the Cotton Research and Development Corporation. The project has ten key activities, four industries, sixteen research partners, and nineteen farmer-managed learning sites across five states.

It is one of thirty-five projects in the Australian Government’s Rural Research and Development for Profit Program.

The potential for significant improvement in water use productivity and business profitability was identified by Smarter Irrigation participants.

The project set out to realise the potential by fostering developments in sensor technology, greatly improved data analysis, and demonstration of improved water use productivity.

Harnessing the learning that can occur when different regions, commodity groups and research institutions interact has been a very effective way of increasing the delivery of new practices.

Smart Automated Irrigation

The core objective was to improve the profitability of irrigated agriculture. However, there is a complex interaction between a number of variables that influence farm profit including water availability, crop yield/quality, irrigation system type (which each have different capital, labour, energy costs) and crop agronomy.

This proposal brought together four of the major irrigation industries in Australia; cotton, dairy, sugar and rice.

The project is based on the premise that improving the application, scheduling and automation of irrigation will reduce costs (such as labour, energy and fertilisers) and increase water productivity and efficiency, resulting in increased profit.

Sustainability outcomes, such as less deep drainage and water-logging, and improved soil health are expected as longer term impacts.

2 Method and project locations

The project consisted of three components.

1. Practical, reliable irrigation scheduling technologies
2. Precise, low cost automated control systems for a range of irrigation systems
3. A network of 19 farmer managed learning sites located around Australia.

The project had key learning sites in;

- **Queensland;** Ayr, Emerald, Warwick, Dalby, Toowoomba, St George.
- **NSW;** Moree, Narrabri, Wee Waa, Tamworth, Aberdeen, Whitton, Jerilderie.
- **Victoria;** Numurkah, Shepparton, Macalister. Goulburn Murray Irrigation District,
- **Tasmania;** Rocky Creek, Sisters Creek, South Riana, Montana, Cressy.
- **South Australia;** Allendale, Eight Mile Creek, Mt Schank.
- **Western Australia;** Harvey.



The location of the major field sites of the project.

This project (RRDP 1801) led and coordinated the Smart Irrigation project.

A set of irrigated agriculture research projects were delivered in partnership with four agricultural industries (dairy, rice, cotton, sugar) across Australia, with fifteen project partners

Smart Automated Irrigation

including four grower groups and many commercial farms. Investigations focused around three key issues of: irrigation scheduling technologies, smart automated irrigation and irrigator led focus farm sites located in major irrigation regions referred to as “optimised irrigation” farms.

Recently there have been advances in remote sensing, satellite imagery and plant based sensors as indicators of crop stress and spatial variability, and the optimisation and automation of irrigation applications but there are few links between these broad areas. This proposal was about taking the best of each technology and pulling it together on operating irrigated farms via the following steps:

1. Irrigation scheduling technologies (plant, soil, weather)

1a) Quantifying the performance of automated satellite/weather-based irrigation scheduling systems with respect to pasture production, irrigation performance, labour costs and management requirements for dairy.

1b) Comparing irrigation strategies for different cotton crops stages, soil types, regions and climatic conditions to identify potential for improvements in productivity and water-use efficiency for cotton.

1c) Integrating tools used for irrigation across different crops, regions and scales to provide the

best information for irrigation decision scheduling decision making.

1d) Evaluation of scheduling tools used in the sugar industry.

2) Smart automated irrigation

2a. Development of a precise and automated control prototype for cotton, sugar and dairy pressurised and furrow irrigation systems in the Burdekin (QLD), Narrabri (NSW), Dalby (QLD) and Tasmania.

2b. A detailed assessment of the irrigation delivery system, energy and water use efficiency, changes in irrigation scheduling, system design, irrigation uniformity on participatory farms and an economic analysis and productivity assessment on performance against benchmarks.

2c. Improved irrigation bay design for dairy pastures. This will involve a demonstration field site operating, monitoring and benchmarking to identify most profitable bay design modifications. Key parameters of more efficient and profitable systems will be proposed.

3) Optimised irrigation farms (energy, water nexus)

3a. An investigation of irrigation layouts to maximise water and nitrogen input efficiencies and reduce capital and operational costs (energy) on three - four grower led focus farm sites in Southern NSW and Victoria.

3b. Grower led systems comparison in the Gwydir Valley, NSW. This will involve an evaluation of the performance of irrigation systems on two grower led focus farms, including water use efficiency, energy use, labour requirements and crop production for four seasons.

3c. Four key demonstration sites will be established on commercial dairy farms in WA, SA, Victoria and Tasmania. The sites will quantify the expected water, energy and labour savings associated with adoption of innovative irrigation technologies over two irrigation seasons, as well as the associated management/skills requirements, maintenance costs and labour and lifestyle implications.

Specifically, activities (this sub project) are shown in the following table.

Smart Automated Irrigation

Objective	Contract Outputs Note R4P means Rural for Profit Program of Commonwealth Government.			Approx Days/year 2017 -18 Final Year
Project Reporting for Commonwealth R4P	Produce Final Project report 30/5/18. Produce Monitoring and Evaluation Report.			10
Project Governance and Coordination	<p>Coordinate six monthly Project Steering Committee in accordance with their Program Agreement MoU and twice yearly Project Partner Meetings (phone/meeting). Tasks include Prepare meeting papers and review minutes Assist with discussions in relation to Smarter Irrigation for profit V2</p> <p>Set agendas and logistics, Participate in and report to meetings, Follow up of Committee decisions, Assist CRDC, Dairy Australia, RIRDC and SRA Executive Management as required, ensuring good governance and accountability, and ensure good communication and linkages across the sub projects.</p>			2 4 4
Research project / program management	<p>Coordinate the nine sub projects through assessment, feedback, and approval of project milestone and final reports. (Nine sub projects / twice yearly). (Note RDC managers are responsible for completing formal assessment of milestones and organisational paperwork re milestone approvals/variations).</p> <p>Provide CRDC May/Nov progress report for this sub project project</p> <p>Outcome (Be the first point of contact for Sub Project Leaders on project issues, Fostering quality assurance of R&D arising from projects, Ensure project monitoring and evaluation to ensure consistent outcomes can be reported against various RDC plans and R4P contract, Fostering project knowledge management and sharing)</p>			12 2
Extension, Knowledge management and communications	<p>Ensure regular review and implantation of extension and communication plan. Make presentations on project progress to Commonwealth, RDC and other audiences. Identify communication stories and potential avenues in partnership with project partners Prompt for and approve stories/reports from sub projects</p> <p>(Note this sub project does not have cash resources to implement actions that maybe suggested in "Extension and Communications Plan).</p>			14
				48

3 Project Outcomes

Project level achievements

The project;

- ✓ Provided scientific leadership and strategy direction
- ✓ Created a project culture to foster collaboration
- ✓ Fostered stakeholder collaboration on a national scale.

This project kept the Smarter Irrigation for profit project on track. It;

- ✓ ensured that all the Commonwealth Milestones were met. It completed the milestone reports and the final report of the project,
- ✓ reviewed over 100 media releases, information sheets, PowerPoint presentations to ensure they complied with investor needs as well as the technical content being correct,
- ✓ coordinated regular research leaders meeting, usually a teleconference as well as the six monthly project steering committee meetings,
- ✓ organized the 2 day annual forum (March 2018),
- ✓ commissioned the independent monitoring and evaluation review of the project completed by Resources Strategies,
- ✓ commissioned and reviewed the knowledge harvest,
- ✓ reviewed milestone reports of the CRDC cotton projects,
- ✓ made public presentations on the project to key stakeholders,
- ✓ acted as the first point of call for the project,
- ✓ compiled farmer case studies of outcomes,
- ✓ hosted tours, events and meetings with stakeholders,
- ✓ implemented the social media Facebook page.

The outcomes were

- ✓ generated knowledge that benefit primary producers
- ✓ strengthened pathways to extend the results of rural R&D, including understanding the barriers to adoption
- ✓ establishing and fostering industry and research collaborations that form the basis for ongoing innovation and growth of Australian agriculture
- ✓ cross sector collaboration between RDCs, research providers and industry.

Contribution to program objectives

The objective of the program was to realise significant productivity and profitability improvements for primary producers, through:

- generating knowledge, technologies, products or processes that benefit primary producers
- strengthening pathways to extend the results of rural R&D, including understanding the barriers to adoption
- establishing and fostering industry and research collaborations that form the basis for ongoing innovation and growth of Australian agriculture.

This project has led to a significant increase in the knowledge of the participants around these areas, namely:

- establishing and fostering cross sector and industry/research collaborations.
- strengthening pathways to extend the results of rural R&D, including understanding the barriers to adoption

Specific examples are provided in other sections of the report.

The Independent evaluation of the project found

“Smarter Irrigation for Profit has been a very effective cross-sector collaboration, generating and extending cutting edge technologies, and working closely with irrigator networks, commercial interests and the managers of ‘optimised’ irrigation farms. “

“The project has built a sound extension network, strengthening existing extension pathways.

The private sector and other regional parties have been engaged by the Project as part of the extension networks, and commercial interests have contributed to the research - providing ideas and innovations for testing, as well as equipment, software and advice.

The cross-sector collaboration, and that between Project investors, researchers, irrigators and the private sector, has been a major contributing factor to the benefits coming from Smarter Irrigation for Profit. Cross-sector collaboration, as part of the Rural R&D for Profit program, was the nucleus around which the Smarter Irrigation for Profit Project formed. It shaped the nature of the Project and has helped address the challenges of a short project (which has in effect been about two and a half years in duration).”

(Source: Resource Strategies Pty Ltd 2018. Evaluation of the Smarter Irrigation for profit project, April 2018.)

A separate independent evaluation of the entire Rural Research for Profit program found

“This project provides a good example of large scale cross industry collaboration, involving multiple RDCs and partner organisations across Australia. Led by CRDC, other partner RDCs included AgriFutures, DAL and SRA.

There are also many partner organisations involved from across university, state government and private sectors, including primary producers, University of Southern Queensland, Tasmanian Institute of Agriculture, CSIRO, NSW Government Department of Primary Industries, DairyTas Board, South Australian Research and Development Institute, Dairy SA, Victorian Government Department of Economic Development, Jobs, Transport and Resources, Gwydir Valley Irrigators Association, Sundown Pastoral Company and Auscott.

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4 Collaboration

The project involved cotton, dairy, rice and sugar irrigators with the support of 16 research and development partners and 19 farmer irrigation technology learning sites. The project also had 19 key learning sites located all around Australia.

The project was led by the Cotton Research and Development Corporation, who partnered with Dairy Australia, Agrifutures Australia, Sugar Research Australia, Victorian Department Economic Development, Jobs, Transport and Resources, Tasmanian Institute of Agriculture, CSIRO, NSW DPI, University of Southern Queensland, Gwydir Valley Irrigators Association, SARDI, and Sundown Pastoral Company, Auscott Ltd.

A project steering committee provided governance and set the strategic direction of the project. Members of the steering committee included; Jane Trindall, CRDC (Chair), Cathy Phelps Dairy Australia, Peter Sampson SRA, Michael Beer Agrifutures, Dougal Wallace Victoria DEDJTR, Peter Regan NSW DPI, Richard Rawnsley TIA and Erik Schmidt USQ.

The project leaders of the core projects included Joe Foley NCEA/USQ, Lou Gall GVIA, James Hills TIA, Hiz Jamali CSIRO, Andreas Jaramillo SRA, Andy McAllister A DEDJTR, Mike Morris DEDJTR John Smith NSW DPI and Monique White Dairy SA. Guy Roth, The University of Sydney led the project.

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“This project provides a good example of large scale cross industry collaboration, involving multiple RDCs and partner organisations across Australia. Led by CRDC, other partner RDCs included AgriFutures, DAL and SRA.

There are also many partner organisations involved from across university, state government and private sectors, including primary producers, University of Southern Queensland, Tasmanian Institute of Agriculture, CSIRO, NSW Government Department of Primary Industries, DairyTas Board, South Australian Research and Development Institute, Dairy SA, Victorian Government Department of Economic Development, Jobs, Transport and Resources, Gwydir Valley Irrigators Association, Sundown Pastoral Company and Auscott.

It is also large and complex in the of number trial sites and their broad distribution across regional Australia. There are 19 sites in total in Ayr, Emerald, Warwick, Dalby, Toowoomba, St George, Moree, Narrabri, Wee Waa, Tamworth, Whitton, Jerilderie, Numurkah, Shepparton, Macalister, Goulburn, Murray Irrigation District, Rocky Creek, Sisters Creek, South Riana, Montana, Cressy, Allendale, Eight Mile Creek, Mt Schank, and Harvey.

From an RDC perspective, this project provides a focal point for greater collaboration across RDCs and the government sector, and this was identified as an area for increased collaboration and extension in the future. It was clear from interviews that project participants value the trust built up across the group, and they felt interests had been balanced and equal participation encouraged. As commented by one project participant:

It’s been a good honest forum. Not like some, where you get into them, and you know the bloke across the table is holding a few cards back.

This project also provides an example of farmer led collaboration, as farmers are collecting the commercially comparative data on different irrigation systems and technologies as they trial the different automated irrigation scheduling systems on farms. Two satellite based scheduling irrigation performance pilots are also being implemented on commercial dairy farms in Northern Victoria. Interviews with RDC representatives commented on how the collaboration has successfully involved farmers as part of the research.

Farmers involved in the project commented on the impact of the project to their farm practices. For example:

I’ve now fully automated the farm. It’s made a massive difference. We have proper records of water usage and we can manage our irrigation much better.

It’s also meant I’ve saved money on hiring people. I was lying in my hotel room in San Francisco and wats still able to turn my pumps on.

The project also evidences how new collaborations between farmers in the sugar, cotton, rice and dairy industries have been formed, via a number of activities such as bus tours of young farmers to other farms and presentation by groups at major workshops. As commented by one farmer involved:

... talking to others, you could see that we faced the exact same issues across industries. It’s good to find out what other people are doing to make me think about how I could apply it differently on my property.

(Source: Grosvenor Management Consulting, 2017, *Evaluation of the Rural Research & Development (R&D) for Profit Program Final Report*, Canberra, 15 December 2017).

Going places: Looking outside the farm, region and industry

A key aspect of uptake and extension has been field days, group and individual visits and research tours to key learning sites and optimised irrigation farms.

The events at these sites serves growers from the industries in two ways. Firstly, it gives producers within industries the opportunity to learn from the researchers and growers from their own and other regions. In some cases it's learning from your neighbour or a producer on the other side of the country.

Secondly, the tours have facilitated important cross-industry information sharing. Under the project, sugar producers have visited large broadacre cotton farms in North West NSW, dairy farmers have travelled interstate and into the cotton and grains regions and rice growers have made several trips to visit the key learning sites at Moree, Wee Waa and South-East Queensland.



Melanie Jenson

Examining soil structure and water holding capabilities has allowed for the implementation of variable rate irrigation at Rob Bradley's farm at Cressy, Tasmania. The findings of the research were presented as part of a dairy industry field day in February 2018.



Melanie Jenson

Irrigators from the sugar industry in North Queensland, rice and cotton growers from southern NSW and cotton growers from all regions of Australia have had the opportunity to discuss all things irrigation at the Gwydir Valley Irrigators Association and Smarter Irrigation for Profit field days at Moree in northern NSW.



Melanie Jenson

Rice and cotton growers from the Murrumbidgee and Griffith region on tour to North West NSW sharing their experiences and learning about automation, field configuration, and the relationship between nitrogen and irrigation. Growers from the southern regions have made several trips to visit the key learning sites at Moree, Wee Waa and South-East Queensland.



Melanie Jenson

Sugarcane farmers made the long trip from the Burdekin to Moree's cotton farm key learning sites, where they saw automation research in the field and talked to leading researchers and technical experts.





Melanie Jensen

Dairy farmers from around NSW and researchers visiting The University of Sydney's Plant Breeding Institute at Narrabri in Northern NSW. "It made us think of new ways to increase our efficiency in our use of water and solar. It was great to see cotton farms up close and see how the laterals and pivots work." - Vernon Brown, Wingham farmer.



Melanie Jensen

Learning about automated irrigation in action at Moree, NSW, from farm manager Ray Fox at a joint GVIA and CottonInfo field day where technology being tested through the project is on show



Melanie Jensen

Dairy farmers from the mainland states out and about on the coast at Rocky Cape, Tasmania. This site showed the true variability of soils types irrigators contend with, and how best to manage them in terms of water use efficiency and pasture growth. The sand dunes visible in the distance are an indication of the extremely sandy soil. Farm owner Luke McNab is managing water use through earthworks and gaining a better understanding of his soil.

5 Extension and adoption activities

The flagship strategy and “beacons” of the project was use of key learning sites. These 19 sites were located all around Australia and were mostly on commercial farms. They all involved farmers, advisers, scientists and agribusiness. Thousands of people inspected or visited one of these sites. Some were more “research” focused testing a hypothesis with replication and robust scientific methods. Some were “demonstration” focused involving monitoring current actions and making changes as experience and confidence grew. One of the strengths of the project was having both approaches.

Other techniques used during the project included;

- Field days, workshops and industry forums
- Newspaper and magazine articles – print and online
- Media Interviews
- Conferences/symposiums
- Online resources
- Videos
- Social media
- Project meetings
- Cross sector bus tours

The role of this project was to coordinate these actions across the industry sectors. The key outcome was the cross sector collaboration between the cotton, sugar, dairy and rice industries continued to develop. This has been achieved through a range of formal activities (projects) and informal actions such as phone calls, emails, social media, bus tours and forums.

Various presentations have been made on the project. For example, a presentation was made to the Department of Agriculture and Water Resources staff in Canberra on 5th July 2017 with Jane Trindall, CRDC. Following the presentation, the Department’s Graduate students contacted Dr Roth for some help with their Departmental project on mini hydro energy generation on farms. Presentations were also made to MDBA, RDCs and grower groups. Another example was a presentation was made in Brisbane 5th September to the Sugar Industry Irrigation Forum on the project and specifically what other technologies other industries (cotton, dairy and rice) are adopting. In terms of outcomes, the project has been significant in influencing sugar industry irrigation RD&E thinking and knowledge sharing from the other sectors as evidenced by the evaluations. Presentations were also made to other groups on the project such as Riverine Plains Cropping Group, Tocal Agricultural College students.

Project material was drafted for the Department of Agriculture and Water Resources Annual Report. The project was featured in the 2017 annual report as a one page case study (Page 24 of their annual report). The project was also featured in the Rural Research for Profit mid-term evaluation.

A considerable amount of time was dedicated to reviewing communications materials of the research team. These included project stories, PowerPoints, media releases and reports. The outcome is knowledge sharing and communication to stakeholders.

Several meetings have also been held on the new irrigation scheduling tools matrix project which is attempting to be a one stop shop of information on all the various soil

Smart Automated Irrigation
-water -plant monitoring sensors that growers might be interested in.

This project has maintained Facebook page and twitter links

Information has been drafted on case studies relating to extension. For example, as follows...

Smarter irrigation in the field

An expected outcome of the *Smarter Irrigation for Profit* project was the adoption of new irrigation technologies and science application by farmers and irrigation professionals to improve farm profits.

In just under three years, the *Smarter Irrigation for Profit* project is realising significant benefits for irrigators as they implement management strategies from research findings and technology trials. Growers have learned from being directly involved in setting the direction for research on optimised farms and key learning sites or from visiting these sites and learning about the research through various other avenues or events. Benchmarking, machinery evaluations and pump monitoring undertaken under the project has also yielded benefits for irrigators.

Glen Price, cotton grower

St George, Queensland



Cotton grower Glen Price (left) is using canopy temperature sensors for irrigation scheduling at his farm in St George, Queensland. Source

Steve Carolan, grower / Andrew Greste, farm manager

“Waverley” Wee Waa, NSW



It takes just one person to irrigate cotton where seven were once needed with the help of automated irrigation and a move to smart siphons at Steve Carolan’s property “Waverley” near Wee Waa in North West NSW. There is 200 hectares under full automation with small Pipes Through the Bank, which have now been set up across the 2200 hectares of irrigated country at “Waverley”. After seeing automation in action at another demonstration site at Moree, Steve and farm manager Andrew Greste initially converted 100 hectares from traditional siphons to a fully automated system. It consists of small pipes through the bank and a series of gates in the channel delivery system which can be remotely monitored, opened and closed by mobile phone. Working under the project with Dr Joe Foley of NCEA, the system has been expanded and refined. Steve says the advantages are labour savings, improved uniformity and water use efficiency.

COMMENTS FROM THE FARMER

“We need better data for better scheduling and the bigger the farm the more data you want.”

“You have to integrate different types of information, as you can’t ask the plant.”

“You can measure the soil water, which is an indirect measurement. I can check them every five minutes if I wanted to.”

“These are the most common tools and the most affordable ones at the moment.”

“Then you have canopy temperature which is the most direct measurement.”

“I receive this output once a week, but hopefully it will become something that I can have access to all the time, which would be really helpful.”

“The graph I receive is really understandable, and I would be happy to pay a fee for continuous access, as long as it is not excessive.”

“Being able to have a graph considering soil moisture and canopy temperature to know when to irrigate would be very handy.”

COMMENTS FROM THE FARMER

“This is not cheap to set up, but we can justify some of the expense over time in terms of savings in labour and improved water use efficiency.”

“This is turn-key irrigation - we easily irrigated with one man where once we’d need seven.”

“In terms of water use efficiency these fields have also gone from a 36-hour to 24-hour turnaround.”

“Our supply and return channels are monitored so we know when to turn our pumps on and off.”

Vic Rodwell, dairy farmer

Boyanup, Western Australia



COMMENTS FROM THE FARMER

"Using soil mapping tools, variable rate irrigation and variable speed pumps has allowed me to reduce my feed costs under the 100 ha centre pivot area. I grow kikuyu under the pivot and have reduced cost from around \$240 to \$130 per tonne of dry matter."

Western Dairy

Rob Bradley, dairy farmer

Cressy, Tasmania



COMMENTS FROM THE FARMER

"We're putting the water where it needs to go, we're using less power to do it, and we're growing more grass."

Mark Horstman

Rob Bradley has increased pasture production by 200 tonnes over 117 hectares with variable rate irrigation under centre pivots. This was achieved through better irrigation scheduling to keep moisture in the root zone for optimal growth using less water. More pasture means less supplementary feed costs and better use of water and energy. With these savings the researchers calculated that the payback time on installing the VRI technology was reduced from nine to two years.

Rex Tout, dairy farmer

Tamworth, NSW



Marguerite White

Rex became involved in the project as an optimised dairy farm.

An expert Technical Working Group provided both strategic direction and technical advice to the project. Based on results from monitoring and assessments, gains improvements on this site included a 21% reduction in the cost of power simply attributed to a correction in the way power was metered, 60% reduction in power use by the irrigation pumps, and an increase of average pump efficiency from 29% to 68%.

As a percentage of annual farm milk income, power costs to pump and place water reduced from 2.93% to 1.8% in one year. In 2015/16 the business was paying \$15.74/1000L of milk produced for power to irrigate compared to a reduction in 2016/17 to \$8/1000L.

The project provided opportunities for local farmers to receive real-time soil moisture and rainfall logging data as well as introducing them to available technologies such as the SID to better inform their own irrigation decisions.

Aaron Linton, sugarcane grower

Ayr, Lower Burdekin, Queensland



Brad Pfeffer

Automation of furrow irrigation has allowed Aaron Linton to better balance a busy business and family life with farming – and also deliver productivity and efficiency.

The Burdekin farmer had already seen the benefits of irrigation automation from the work he had done installing a drip system at his Leichhardt farm. So when the opportunity arose to expand the automation to his furrow irrigation on the same farm, he jumped at the opportunity.

He encouraged anyone who was interested in automation to calculate, factor in and value their own time.

COMMENTS FROM THE FARMER

“Even if I save three trips per week, this equates to 11,000km per year, and in reality I was saving a lot more than that without even fully realising it.”

“That equates to about 110 hours or a whole month of work for someone in a nine to five job, so that is a lot of time that I can spend on other businesses, family, my own time, or being able to sleep at night.”

“It does seem expensive when you are going to install it, but the benefits are worth it.”

“With electricity, if you miss the changeover for a tariff, the cost can switch from say 17 cents to 48 cents.”

Andrew Farr, dairy farmer

Denman, Hunter Valley, NSW



Hunter Valley dairy farmer Andrew Farr says a trip to the North-West’s cotton and grain fields was a very worthwhile experience.

Andrew and Christie Farr run 400-head milking operation, with irrigated pasture, and dryland cereal cropping on their 960-acre farm “Rossette Park” at Denman.

The dairy farmers were from more southern areas of NSW, and toured cotton farms, grain research facilities and the CRDC head office in Narrabri.

Andrew said a big message was the need to monitor and measure to manage.

COMMENTS FROM THE FARMER

“There is definitely a lot more monitoring going on down that way.”

“I think in that environment, water scarcity and price has driven a lot of improved water use efficiency, which includes better and more monitoring.”

“It was quite obvious and made clear throughout this tour of the need to measure water use.”

“When the time is right I will be putting in place the technology to do this.”

“I can see how irrigation technology will allow us to make gains in our systems, with improved efficiencies, even on a small scale, making all the difference.”

“Whether you’re a big business or a one percenter, incremental savings through better efficiency all add up and can make all the difference.”

“It may not push up your top yield so much, but will bring up your bottom yields – that’s where you get your biggest gains.”

“Improving your average across the board is how we do it.”

Hoffman family, dairy farmers

Warwick, Queensland



David Hall

COMMENTS FROM THE FARMER

“A commissioning audit of the pivot found that both the water application depth and the uniformity could be improved.”

“As a result of the Smarter Irrigation project we have made changes to our practices and are now producing more feed from the same amount of water.”

“The project also assisted us to address a range of soil constraints that were reducing our crop yields.”

Mick Giumelli

Western Australia



Western Dairy

COMMENTS FROM THE FARMER

This [Smarter Irrigation for Profit Project] was an easy, insightful and enjoyable experience. The main thing I have learned is that water application and the right timing go hand in hand. I have also learned that technology is a farmer’s friend and will aid us immensely going forward.”

“I also would like to plant the lablab again, but over a larger area and implement it into our system. I am also open to trialing other crops.”

Wayne Seward, dairy farmer

South Riana, Tasmania



Mark Horstman

COMMENT FROM THE FARMER

“The timing of everything was the biggest learning for me. It’s possible to over irrigate and under irrigate on this site, I also understand more about readily available water (RAW).”

John and Karen Hunt, dairy farmers

Allendale East near Mount Gambier South Australia



Dairy News Australia

COMMENTS FROM THE FARMER

“I thought the soils were causing the waterlogging but a catch can test showed the pivot was inefficient. This was costing us over \$14,000 in lost production.”

“It was easy to go to the bank for the money to replace the sprinkler pack and regulators - payback was less than a year.”

Gwydir Valley Irrigators Association

Moree, NSW



Each year the Gwydir Valley irrigators Association (GVIA) has held a major field day to explain their key learnings to hundreds of irrigators and farm advisers. They have produced videos and fact sheets that can be found on their website.

GVIA's trial and key learning sites have been integral for researchers to implement research and then as tools to extend the knowledge more broadly throughout the rice, cotton, sugar and dairy industries.

Russell Jordan, sugarcane farmer

Burdekin, Queensland



Brad Pfeiffer

Russell Jordan farms sugarcane in North Queensland. On one farm which is 104 ha his irrigation system is 100% gravity operated meaning it requires no mains power for pumping. His farm is an example of automation on a gravity feed system. There are five automated valves and a series of sensors in the field which switch on and off the water. Russell's motivation was to eliminate runoff as water is expensive.

He needed to visit the farm several times a day when irrigating, but automation allows him to visit once a day and importantly when it suits him, rather than when the water needed changing. Russell's water and time savings and increased confidence in automation are encouraging him to adopt more automation.



<https://sugarresearch.com.au/caneclip/automation-furrow-irrigation-russell-jordan>

Ray Thornton, maize grower

Numurkah, Victoria



Melanie Jenson

Ray Thornton talking about the impact of irrigation schedule on plant development and the seasonal differences he saw at this site due to differences in timing of the hot weather between the seasons.

The outcome of this site is that Ray and one of his neighbours have changed their irrigation schedule to what was our 'short' deficit because of increased grain yield and also because our work here with soil monitoring highlighted that with the fast watering automated system he was not refilling the soil water profile properly. He was sceptical of the reduced deficits at first but has now put the irrigation management across the farm. He went from a seven to a five day turn around.

COMMENT FROM THE FARMER

"I've gained so much it has been great working with them (SIFP) and am pleased I spent the money on the technology."

Nigel Brock, dairy farmer

Montana, Tasmania



Melanie Jenson

Nigel Brock and researcher James Hills of the Tasmanian Institute of Agriculture have been working to improve irrigation efficiency with centre pivots, variable rate irrigation and the VARIwise platform.

COMMENTS FROM THE FARMER

"I learned a lot more about how to use the VRI on my pivot. I've learned to look at evapotranspiration figures from the Bureau of Meteorology and found that soil moisture sensors are a useful method for identifying when to commence irrigation at the start of the season."

"The result of the VRI working effectively has saved water mainly because the water is used in the right place and at the right rate, not wasted on roads and drains etc. Using the VRI we can also differentiate between the sandy hills and the clay loam flats and apply the correct irrigation amount to maximise pasture production in both areas. In the past with conventional pivots this was a real balancing act."

"Throughout the project we have become more aware of the importance of the design, measuring, mapping and energy components of irrigation. Knowing what you have got and how to use it can be a big advantage. The project team helped explain all aspects of using the technology to full advantage. We were doing an okay job of irrigating prior to the project but a much better job after. So much so that we will definitely be using VRI technology on the new pivot."

Mahesh Singh, dairy farmer

Gippsland, Victoria



Sarah Killury and Alexis Killoran

COMMENTS FROM THE FARMER

"The irrigation timers are the best thing to have happened to the irrigation system on this farm. I have time to spend with my family, and I don't have to be up at all hours through the night."

"In the future it is a lot more attractive to workers to have some irrigation automation on the farm."

"However, the channels have to be clean, and you must keep to the same pattern of irrigation or else all the timers need adjusting."

Terry Wilson, dairy farmer

Donovan's Dairying, South Australia



Monique White

COMMENTS FROM THE FARMER

"We installed a range of soil moisture monitoring for the Smarter Irrigation project."

"At the end of the irrigation season it enabled me to decide if we could wait an extra day before irrigating."

"Getting it wrong would cost us pasture, all I had to do was check the graphs using my phone and I could make an informed decision."

Nick Ryan, dairy farmer

Gippsland, Victoria



Peter Day

Farm manager Nick Ryan – second from right) and research team Amjed Hussain, Des Whitfield and Andy McAllister



Peter Day

Automated outlet riser from a pipe source.

COMMENTS FROM THE FARMER

“My irrigation practice has generally been conservative because I generally wanted to irrigate a day before that which is indicated from the experimental system.”

“I have also tended to have irrigation durations longer than what the model is indicating.”

“It’s been a good learning process for me and the researchers to try and refine our irrigation practice.”

Denis Pozzebon, sugarcane farmer

Burdekin, Queensland



Brad Pfeffer

COMMENTS FROM THE FARMER

“Through a Sugar Research Australia project I became involved because I have always had an interest in automation of irrigation and saw that it would be the way of the future.”

“The experience with this project has been a real eye opener and has been everything I have expected, probably more.”

“It starts with an improvement to social life by being able to spend more time with family and to be able to travel away and not worry about irrigating this section of the farm.”

“It has also included savings to water and energy.”

“It is an investment in the long term that has to be looked at over five to 10 years. It may not stack up in the short term, say two years, but with energy prices skyrocketing every year and water prices going up, I see this as an investment in the future.”

Mat Stott, cotton grower

Point Farms, Darlington Point, NSW



Iva Quarisa

Field days at Mat Stott's 'Point Farms' at Darlington Point have provided valuable information to farmers new to cotton.

At a key learning site in the Griffith region, using data from a three-year trial, altering his cotton irrigation schedule to a seven-day strategy has resulted in between three quarters and one bale/ha greater yield for Mat Stott.

COMMENTS FROM THE FARMER

"Coming from a corn growing history, we were using similar scheduling and tended to water our cotton too often."

"As a result of the trials we have changed our irrigation scheduling, which has resulted in roughly three quarters of a bale more yield."

"What was surprising is that we found we were causing a yield penalty from overwatering."

"Working on a seven-day cycle, but still tailoring watering to the weather and climate, we will slow down or speed up when we need to."

"Every farm is different, so what we are trying to show at these sites is that you can adapt what you see here to make it work on your farm."

"I think the site has been beneficial for the region in terms of giving interested growers and researchers access to the crop first hand."

"By being involved we have had outside agronomists and other researchers come onto the farm at field days and individually to look at the wider cropping area, and they all bring information to us."

"I'll be continuing irrigation research here with some of the current partners after the Smarter Irrigation Project finishes up."

Antony Vagg, farm manager

Rice Research, Jerilderie, NSW



Melanie Jensen

COMMENT FROM THE FARMER

"Being a part of the trials has inspired us to undertake further research into rotation options and short season rice varieties to take advantage of soil moisture after harvest."

6 Lessons learnt

There are many lessons from this project are summarised below.

Irrigation system design and function

- Benchmarking is an important first step to establish a base line from which gains in productivity and efficiency can be measured.
- Centre pivot system designs receive less attention than they should. Irrigators are predominantly price driven when making decisions for new irrigation infrastructure. This can result in a system with higher ongoing energy costs over its life.
- Evidence suggests a higher initial spend on capital (pipes, pumps) can reduce ongoing energy costs. To seal the deal, suppliers sometimes compromise on critical aspects, like pipe diameters, which reduces costs for the service provider and increases energy usage for the owner.
- Sometimes systems are often installed and paid for without having the design specifications validated.
- PUR (pump utilisation ratio) is an important metric. Keeping PUR high, is an indication the system is well designed. Centre pivots are designed to keep moving, it is possible to over capitalise and have the machine parked (not being used) lowering PUR.
- Understanding the difference between system capacity and managed system capacity and the trade-off between risk mitigation and capital costs are important.
- The higher the total dynamic head (TDH) the higher the energy demands.
- Nozzle charts and monitoring machine performance against designed specification is important. A Nozzle chart is an important document provided from nozzle manufacturers' outlining system capacity of the pivot, flow rates required (L/S), the span length (in metres), irrigated area and the nozzle sequence. Centre pivots are designed on a specific site basis so the metrics these charts provide are an essential point of reference.
- Variable speed drives are often not set correctly which results in the system under-performing.
- As topography and soil type changes with each site there is no "one size fits all".
- Consideration of infiltration rates on different soil types are critical with pivot design as water needs to reach the crop root zone and if instantaneous application rates exceed soil infiltration rates substantial levels of runoff are generated.
- Modified bay surface can improve the performance of any bay that ponds excess surface water, for the modified bay to reach its potential it must be implemented as part of a well managed, efficient, modernised and automated surface irrigation system.
- The project highlighted that there are many unknowns when you progress towards new technology. For example, the planning required, and costs associated with installing small pipes through bank was more difficult than initially anticipated.

Available soil moisture and irrigation scheduling

- Understanding the soils readily available water content, the system capacity of the irrigator and the evapotranspiration rate is important in determining when to schedule irrigation and how much to apply.
- Overwatering and under watering are equally as bad.
- The green drought - the expensive implications of getting irrigation scheduling wrong. The “green drought” is a scenario where a farmer irrigates, and the soil moisture deficit is already below the refill point. This means the plants must work harder to obtain moisture than in an optimal situation. As a result, plants stay green but without any active growth. The only way to exit the green drought is for the pivot’s irrigation applications to exceed ET for a number of consecutive days or a significant rainfall event to refill the soil profile. Keeping soil moisture levels in the RAW zone is critical in getting productivity gains from irrigation. In pastures, close monitoring of soil moisture is required as rooting depth of plants are shallow (30cm) in comparison to other crops and soil moisture levels can be depleted beyond the refill point in a matter of days.
- Measure to manage is an important principal. Irrigation can give farmers false assurance, water being applied does not necessarily mean water is being utilized effectively on a dairy business. Water on and water off principal needs to be understood which means putting the right amount on at the right time and in the right place.
- There are many soil moisture, plant based and weather based tools. They all have pros and cons. Better soil moisture technology is needed – this is a holy grail for research. More robustness is needed with more sensors and this is improving.

Variable rate irrigation

- Return on investment in VRI technology depends on growing more grass or crop. For example, increasing pasture utilisation by 1t DM/ha through the application of VRI technology will reduce the return on investment from 9 years to less than 3 years compared with savings from reduced water inputs alone.
- VRI interfaces and the map creation required to maximise benefits can be complex and time consuming, but significant benefits can be achieved by accounting for the basic factors such as avoiding irrigation applications to laneways, waterways and wet areas.
- During the growing season there are often changes in the spatial distribution of growth in the crop or pasture. Irrigation scheduling may call for a different water application rate to the different management zones as crop water demands change. This may require uploading of up to three zone control maps to the control panel and then choosing the appropriate zone map as the growing season progresses.

Pathways to Adoption

- The flagship strategy of the project was use of the key learning sites. These 19 sites were located all around Australia and were mostly on commercial farms. They all involved farmers, advisers, scientists and agribusiness. Thousands of people inspected or visited one of these sites. Some were more “research” focused; testing a hypothesis with robust scientific methods. Others were “demonstration” focused involving monitoring current actions and making changes as experience and confidence grew. One of the strengths of the project was having both approaches.
- A key learning from this project is the extent of the opportunity to improve water

Smart Automated Irrigation

productivity on Australian irrigation farms still remains. Examples in this project were found from both good and not so good irrigators. This extent is huge.

- This difference in culture in some sectors has slowed the rate of uptake of new technologies and practices to improve water productivity in comparison to other sectors.
- The initial perception of some of the farmers participating in this project was that they were relatively efficient users of water and the hook for participating was the opportunity to assess new technologies. The finding that even the 'best' farmers are not getting the 'basics' right represents an opportunity to significantly increase farm profit at relatively low cost.
- The project identified significant knowledge barriers to realising this opportunity. These barriers were;
 - lack of awareness that there are low cost options to improve water productivity,
 - poor understanding among farmers and service of the benefits of regular maintenance and system checks,
 - the complexity involved in using and interpreting scheduling support tools, and;
 - limited access to trusted service providers with the requisite skills and knowledge to provide appropriate advice and services.
- Additional barriers were the perceived cost of upgrading irrigation equipment and the challenge of managing multiple paddocks under a rotational grazing or cropping system.
- Traditional extension approaches such as demonstration sites will assist in building knowledge and awareness of the importance of getting the 'basics' right.
- Not all personnel in the irrigation sector understand that the unique nature of on-farm irrigation systems requires a tailored approach to improve each irrigation manager's skill-set and allow measurement and evaluation of their own irrigation system's performance. While traditional irrigation extension has been about exploring generic themes across particular regions and irrigation system types, this is not always advantageous, as the perceived commonalities across irrigation systems can still be undone by individualised mis-management of individual irrigation events.
- Convenient, simple field ready tools for objective irrigation decision making are essential then to allow growers to improve the irrigation performance of each and every event in which they are involved. It is clear that despite the great motivation and enthusiasm of all involved in the irrigation community, technical education to improve performance of irrigation equipment and irrigation management is still needed.
- Even for the leading growers in their respective industries that were involved in the Smarter Irrigation for Profit project, performance improvements in individual irrigation events are possible, and significant gains have only been made with individualised attention and measurement of difficult aspects of their irrigation system.
- Projects need to simplify or at least consider complexity in the on-farm and decision-making components that an irrigator requires to develop a robust irrigation schedule. The current complexity in irrigation scheduling equipment (i.e. soil moisture monitoring) means that irrigators need to spend time interpreting and analysing data to arrive at irrigation decisions.
- The program could benefit from less emphasis on technology and more emphasis on the farming systems, irrigator behavior and how we move to improvements in irrigation scheduling and then what role technology will play in this.
- Field experiments run on commercial farms are attractive because the experimental treatments can be cost-effectively evaluated at scale and under commercial conditions.

Smart Automated Irrigation

The experiment site can also be used to demonstrate the new technology or innovation applied on a real farm, so results can be more directly relevant to farmers. However, experiments run on commercial farms that impinge on existing farm management practices are unlikely to succeed. With the best will, the objectives and priorities of the farmer for the experiment paddock and those of the researcher will not be the same. Non-treatment effects and confounded results will ensue.

- The project has continued to demonstrate that growers need realistic commercial assessments of tools and technologies to enhance the potential for adoption. Survey responses show that irrigation investment decisions will be made based on a balanced assessment of all the drivers, not simply on the need of one driver such as water use efficiency.
- Indications are that irrigation investment decisions will be carefully assessed, possibly taking several years as they are usually a transformational change.

Collaboration

- There is much evidence within this project of the benefits of cross sector collaboration. All participants rated this aspect of the project highly and they reported the collaborative networks helped build their knowledge and fostered innovation. For example, while it may seem old fashioned the cross sector and intra-regional bus tours were popular with farmers who undertook these.
- Cross-industry collaboration is also challenging but it has been highly motivating for collaborative efforts. Continued funding in the same manner will help on-going collaboration and engagement between cross industry partners, research providers and growers now motivated to measuring irrigation systems and improving irrigation performance.
- Collaboration between diverse project partner organisations provides beneficial research and development opportunities, including access to a wide range of skills and expertise. However, good communication between these partner organisations is essential, particularly in the early stages of a project to ensure all participants have a clear understanding and expectation of their roles and responsibilities.
- The involvement of growers is paramount in this type of project in order to keep practical, demand driven research on track. There needs to be a balance between the practical demands and the scientific goal of understanding the 'why' behind experiment results, to enable successful development of the program of work and the completion of project outcomes.
- Most researchers focus on a specific crop or cropping system as such research is funded by a specific funding body. This project and the Rural R & D for Profit Program in general provided a unique platform for researchers generally working in a cropping system to share, learn and apply such knowledge across industries. The project was coordinated and ran smoothly in a collaborative spirit.

Project Operations

- This project was the first large project within the Rural Research for Profit Program. As such many subsequent projects have benefited and been able to improve project administration systems.
- It is well known that in any partnership it takes a while to develop trust. This project worked hard at this in the beginning. As time has gone on the RDCs have got used to

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collaborating with other RDCs as they have partnered in many other Rural Research for Profit projects.

- If a second project was confirmed more resources could be allocated to communications. The subsequent project could springboard off the first project and has plenty to talk about. Now that there are outputs a project web site or home would be useful as well as an intranet service for project leaders.
- Greater alignment between the Commonwealth Contract and the RDC sub contract project milestone contracts would make whole of project reporting more efficient.

7. Appendix - additional project information

7.1 Project material and intellectual property

A separate report was commissioned in relation to the project intellectual property.

7.2 Equipment and assets

Nil

7.3 Media and Communications

This project reviewed over 100 media articles, field day handouts, PowerPoint presentations and other relevant documents that were submitted by the research team.

It also introduced social media Facebook page for the project.

Articles, project summaries were prepared for the Commonwealth and CRDC

Presentations were made on the project such as Murray Darling basin Commission Presentation, Canberra Feb 2018, Australian Government Department of Agriculture and water Resources Presentation 2017, House of Representative Inquiry into WUE in Narrabri.

The project hosted several visitors such Dairy and cotton irrigator bus tours to The University of Sydney Farm.

The project produced "A project Snapshot" and Grower Case Study Reports.

7.4 Evaluation Report

The independent evaluation report is attached.

7.5 Budget

Complete financial statements will be provided in 60 days as per contract requirements.